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PATENT TRADEMARK OFFICE

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MEMBRANE POSITION CONTROLClaim of Benefit of Provisional Application

5 Pursuant to 35 U.S.C. §119, the benefit of priority from provisional application 60/161,113, with a filing date of October 22, 1999, is claimed for this non-provisional application.

Cross Reference to Related Cases

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~~This application is related to co-pending, commonly owned patent application Serial No. _____, filed October 23, 2000, entitled "Polymer-Polymer Bilayer Actuator", and co-pending, commonly owned patent application Serial No. _____, filed October 23, 2000, entitled "Non-~~
15 ~~Uniform Thickness Electroactive Device."~~

Origin of the Invention

20 The invention described herein was made by an employee of the United States Government and a National Research Council Research Associate and may be used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

Background of the Invention

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Field of the Invention

The present invention is generally related to the control of membrane structures by electroactive bending actuators.

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Description of the Related Art

Membrane inflatable and deployable space structures are widely employed by the government and commercially as reflectors, antennas, solar arrays, satellites, solar sails, etc. Although these membrane inflatable and deployable structures are widely used, many challenges exist which limit their performance for high precision applications. Factors affecting precision include surface smoothness, deviation from desired surface profile, surface deformations due to thermal fluctuations, and accurate membrane positioning. Actuation devices are used for many applications, including the shaping, tuning, positioning, controlling and deforming of membrane structures. To operate most effectively in the aforementioned applications, actuation devices require sufficient force and strain, and often need to produce complex motions.

Conventional piezoelectric ceramic, polymer, and composite actuators (including piezoelectric, electrostrictive, and electrostatic) lack the combination of sufficient strain and force to most effectively perform the aforementioned functions. Previous concepts for shaping and tuning membrane structures have primarily involved the use of piezoelectric ceramic materials. These ceramic piezoelectrics have the major problems of large mass, high density, low strain and high brittleness. Generally, piezoceramics also need additional mechanical devices to achieve a shaping, tuning, positioning, controlling or deforming function. In contrast to electroceramics, electroactive polymers are emerging as new actuation materials due to their enhanced strain capabilities.

Summary of the Invention

Accordingly, an object of the present invention is to provide an electroactive position control device.

Another object is to provide an electroactive position control device wherein the electroactive components have small mass, low density, high strain and low brittleness.

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Another object is to provide an electroactively-controlled membrane.

Another object is to provide an electroactively-controlled membrane inflatable and deployable structure.

Another object is to provide an electroactive position control device using electrostrictive bending actuators.

Additional objects and advantages of the present invention are apparent from the drawings and specification that follow.

In accordance with the present invention, a membrane structure includes an electroactive device fixed to a supporting base. A connection means operatively connects the electroactive device to the membrane for controlling membrane position.

Brief Description of the Drawings

A more complete appreciation of the invention and the many of the attendant advantages thereof will be readily attained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 illustrates a membrane structure having integrated electroactive positioning actuators.

FIGs. 2A through 2D illustrate four positioning states of a membrane.

FIG. 3A illustrates a connection means operatively connecting the electroactive device to the membrane for controlling membrane position.

FIG. 3B illustrates a side view of FIG. 3A.

FIG. 3C illustrates a partial cross-sectional view of FIG. 3B.

FIG. 4 is an alternate embodiment of the connection means.

Detailed Description of the Invention

Referring now to the drawings, and more particularly to FIG. 1, a membrane structure according to the present invention is shown and referenced generally by the numeral 100. Membrane 110 is to be controlled. Membrane 110 can be of any shape. Supporting frame 140 supports the

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membrane 110. Supporting base 120 is connected to a strut assembly 130. Strut assembly 130 is connected to additional structure within the overall structural system. The supporting base 120/strut assembly 130 structure is indicative of usual support and overall system interface for membrane structures; however, the present invention is not limited to such specific configuration. Actuators 150, 160 and 170 are affixed to supporting base 120 adjacent to the supporting base 120 periphery. Actuators 150, 160 and 170 bend upon electrical activation. Electrostrictive actuators are preferred due to their high mechanical modulus and strain combination. An especially preferred actuator is the polymer-polymer actuator described and claimed in "Polymer-Polymer Bilayer Actuator", Serial No. _____, filed October 23, 2000, hereby incorporated by reference. The actuators 150, 160 and 170 can also have non-uniform layer thickness, as that described in and claimed in "Non-Uniform Thickness Electroactive Device", Serial No.

_____, filed October 23, 2000, hereby incorporated by reference.

Referring to FIGs. 2A through 2D, connection means 180 operatively connects the membrane 110 and actuators 150 and 160. FIGs. 2A through 2D illustrate four positioning states of a membrane 110. The actuators are in their inactivated state in FIG. 2A. FIG. 2B illustrates tilting of the membrane 110 resulting from bending of the actuator 150. FIG. 2C illustrates tilting of the membrane 110 resulting from bending of the actuator 160. FIG. 2D illustrates a state in which the membrane 110 is raised as a result of bending by both of the actuators 150 and 160. The bending contour of each of the actuators 150 and 160 will depend upon their materials, their drive voltages, whether they have non-uniform layer thicknesses, as well as other variables, such as electroding methodology. For ease of illustration, displacements of only two actuators, 150 and 160, are shown. It should be understood that none, one, two or three actuators may be electrically activated at any time. The states shown are merely illustrative and positioning capability of each actuator is tailorable via the actuator design, placement and number. Furthermore, any number of actuators may be used, although the three-actuator placement is preferred to obtain the most stability and degrees of freedom.

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FIGs. 3A through 3B illustrate one embodiment of connection means 180. FIG. 3B is a side view of FIG. 3A. FIG. 3C illustrates a partial cross section of FIG. 3B. Bending actuator 160 is affixed to supporting base 120. Either chemical or mechanical means may be used. Chemical means are preferred, such as the chemical adhesive epoxy. The amount the actuator 160 overlaps the supporting base 120 depends on the affixation means employed. The size, including length, width and thickness, of the actuator also vary depending on the desired range of bending displacement that is desired and are selected accordingly. The actuator 160 is movably connected to membrane 110 via a guiding track 210 and guiding wheel assembly, wherein the guiding wheel assembly includes the guiding wheels 200 and axle 220. The guiding track 210 is affixed to the membrane 110 by chemical or mechanical means. Mechanical means are shown. The guiding wheels 200 maintain movement of the axle 220 along the guiding track 210, and are positioned along the axle 220 a sufficient distance from the guiding track 210 to allow free movement of the axle 220 along the guiding track 210. The guiding track 210 and guiding wheel assembly may be plastic, metal, or other suitable material. Plastic is preferred due its lower weight. Guiding axle 220 is affixed to the bending actuator 160 using chemical, such as epoxy, or mechanical, such as fastener, means. The connecting means 180 allows for rotation of the bending actuator 160 in a positive direction, i.e., in the direction towards the membrane, and back to its non-activated position. In operation, the bending actuator 160 responds to the output of one or more sensors located on membrane 110 via an integrated feedback control system. As the bending actuator 160 bends due to electrical activation from a drive voltage (not shown), the guiding wheels 200 translate along the guiding tracks 210, and displacement of the membrane 110 is effected. Another embodiment of the connection means 180 is illustrated in FIG. 4. In this embodiment, guiding track 310 guides upper and lower guiding wheels 300. Any connection means that effectively translates motion of the actuator 160 to the membrane 110 is acceptable.

Obviously, numerous additional modifications and variations of the present invention are possible in light of above teachings. It is therefore to be

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understood that within the scope of the appended claims, the invention may be practiced otherwise than is specifically described herein.

What is claimed is:

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